A prototype personalised liner for lower limb amputees: design, manufacture and preliminary test results

E. Seminati[1,2*], D. Canepa Talamas[3], V. Dhokia[3], M. Young[2], M. Twiste[4,5] and J. Bilzon[1,2]

[1]University of Bath, Department for Health, [2]Univeristy of Bath, CAMERA Centre, [3]University of Bath, Department of Mechanical Engineering, [4]University of Salford, School of Health Sciences, [5]United National Institute for Prosthetics & Orthotics Development (UNIPOD), University of Salford

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Summary

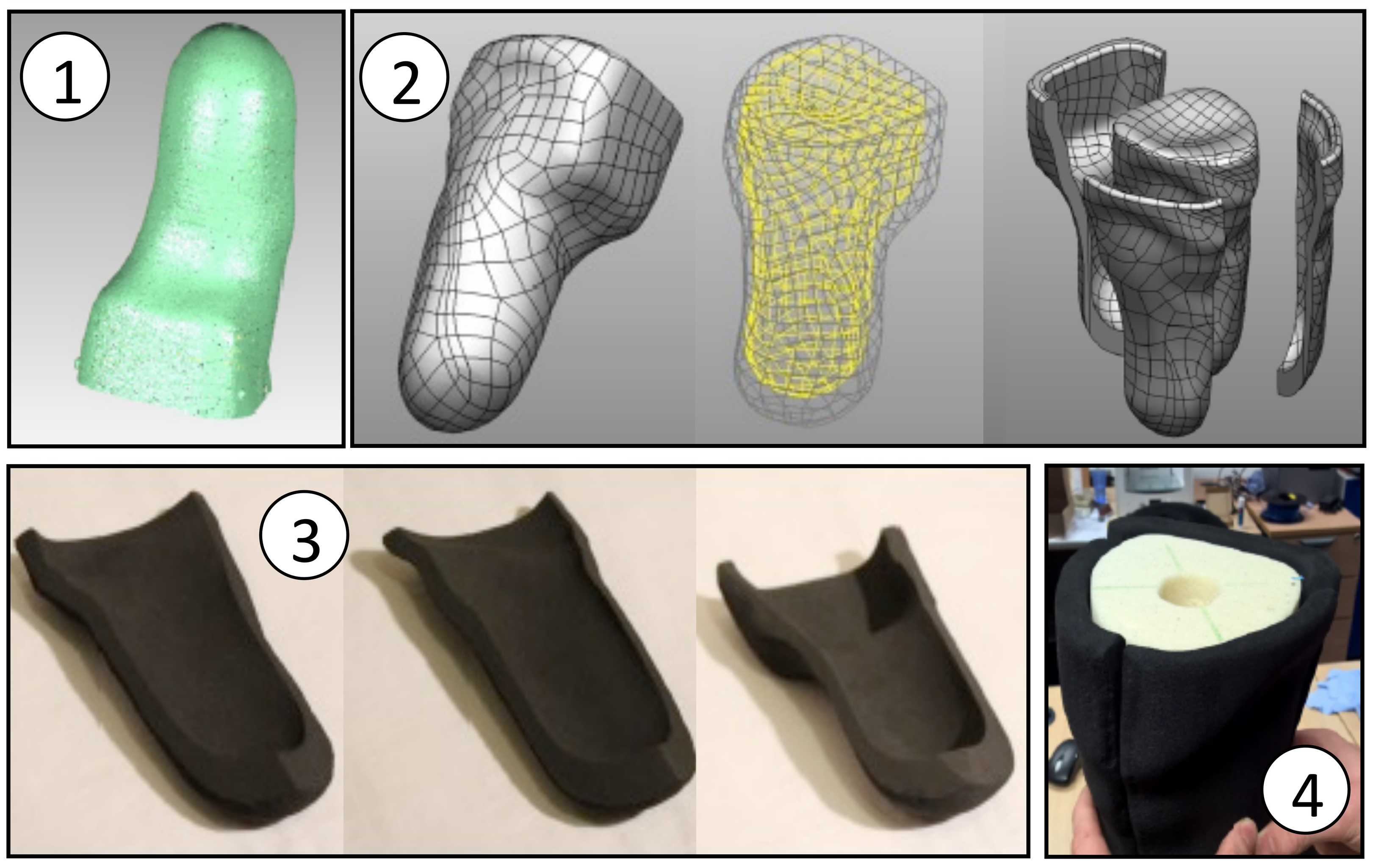
Despite the development of complex and robotic prostheses, **the inner liner remains a critical component of the prosthesis**. This study presents a novel data driven design and manufacture methodology that enables the creation of fully personalised residuum liner for a transtibial amputees, able to reduce the stress on residuum up to 50%.

Introduction

- **A prosthetic liner is the interface between the residuum and the prosthesis**, to enable **correct fitting**, reduce friction and compensate for residuum volume changes post amputation.
- The liner comfort determines the daily duration for which patients use their artificial limbs and prevents further pathological issues (1).

This study presents the design, manufacture and preliminary tests of a fully personalised prototype residuum liner for a transtibial amputee.

Methodology



1. A transtibial residuum model was 3D scanned to create a residuum digital model.
2. The liner was designed with a uniform thickness applied to the outside perimeter of the model.
3. Using the **cryogenic** Computer Numeric Control methods (2), the liner was machined in 3 components. Physical alteration of **neoprene foam** enabled the precise and rapid generation of the personalised liner.
4. The liner encapsulated the residuum model.

5. Surface pressure sensors were placed on the resin transtibial residuum model.
6. The liner encapsulating the residuum and sensors was inserted in a 3D printed socket.
7. The liner was tested according to a modified ISO 10328 for prosthetic component, using a dynamic & fatigue testing system (Instron, UK). Static test: 0 - 2400N at 100N/s; dynamic test: 0 - 1350N at 1Hz (5 cycles). 6 trials were performed for each condition.
8. The same procedure was repeated with common socks replacing the liner.

Results

Max pressure in Static conditions in kPa (mean ± SD)		
	Liner	Socks
Fibula Head	82.1 ± 4.9	89.9 ± 4.4
Tibia Crest	28.8 ± 2.8	35.1 ± 3.0
Cut end of the tibia	81.9 ± 1.1	198.9 ± 1.6#

Max pressure in Dynamic conditions in kPa (mean ± SD)		
	Liner	Socks
Fibula Head	31.3 ± 1.5	42.4 ± 1.2#
Tibia Crest	9.7 ± 0.4	17.2 ± 0.4#
Cut end of the tibia	39.4 ± 1.7	91.1 ± 1.3#

 # indicates statistical differences (from paired t-test) between the pressure measured with the liner and the socks.

Conclusions

- During both conditions, all pressures were lower with the liner than the sock, which highlights the importance for cushioning the residuum.
- Designs based on scanning and data driven methods for multiple material thicknesses and densities may further reduce pressures.

Further works

- New liners will be machined using different materials and different thicknesses.

REFERENCES

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***CONTACT:** Dr E Seminati | e.seminati@bath.ac.uk - @elenaseminati

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Centre for the Analysis of Motion, Entertainment Research and Applications